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Inventor(s): Snodgrass et al.

What is claimed is:

1. A method for communicating between a first transceiver and a plurality of transceivers, the first transceiver and each transceiver of the plurality being coupled to a medium on which a collision occurs when more than one transceiver of the plurality transmits simultaneously, the first transceiver comprising means for collision detection, the method comprising the steps of:
 - 10 a) transmitting from the first transceiver a first signal characterized by an address of a first subset of a predetermined set of designations;
 - b) establishing, in each transceiver of the plurality that was addressed by the first signal, a self designation selected from the set;
 - 15 c) transmitting from the first transceiver a second signal characterized by an address of a second subset of the set, the membership of the second subset being selected by the first transceiver in response to collision detection; and

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d) transmitting a reply signal from a transceiver of the plurality that was addressed by the second signal, the reply signal characterized by the transceiver's self designation;

5 whereby the first transceiver can determine a successful second subset by detecting collisions and narrowing the membership of the second subset, then use the successful second subset to reduce the likelihood of collisions in subsequent communication.

10 2. The method of Claim 1 wherein the second signal further comprises a command packet.

3. The method of Claim 2 wherein the address of the subset further comprises a branch code and a mask code in the command packet.

15 4. The method of Claim 2 wherein the address of the subset further comprises a high code and a low code in the command packet.

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5. The method of Claim 2 wherein a bound code is used within a transceiver of the plurality, and the address of the subset further comprises a limit code in the command packet.

5 6. The method of Claim 3 wherein a transceiver of the plurality concludes that it was addressed by the second signal when the branch code is equal to the result of the self designation logically ANDed with the mask code.

10 7. The method of Claim 4 wherein a transceiver of the plurality concludes that it was addressed by the second signal when the self designation is not greater than the high code and the self designation is not less than the low code.

15 8. The method of Claim 5 wherein a transceiver of the plurality concludes that it was addressed by the second signal when the self designation is comparatively between the limit code and the bound code.

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9. The method of Claim 1 wherein selecting a subset in response to collision detection further comprises a method for selecting an untested subset after use of an initial subset, the method comprising the steps of:

- 5 a) if a collision occurred, dividing the initial subset into an untested right subset and an untested left subset, the initial subset becoming the immediate superset of the untested right subset, the untested right subset disjoint from the untested left subset and selecting the untested left subset whereby the untested left subset becomes a tested left subset;
- 10 b) if a collision occurred and the initial subset cannot be divided or if a collision did not occur, selecting the untested right subset disjoint from the initial subset whereby the untested right subset becomes a tested right subset; and
- 15 c) if a collision did not occur, considering individually each immediate superset of the initial set until a tested left subset is under consideration and selecting the untested right subset that is disjoint from the tested left subset under consideration.

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10. The method of Claim 1 wherein selecting a subset in response to collision detection further comprises a method for selecting an untested subset after use of an initial subset, the untested subset being one of a hierarchy of subsets, the hierarchy having levels arranged from a root level, the root level having one subset comprising the full set of designations, each subset at any one level being disjoint from all other subsets at that level, each subset at any level being the proper subset of only one subset at a level closer to the root level, the method comprising the steps of:

- a) recording that the initial subset does not require test;
- b) if a collision did not occur, recording for each proper subset of the initial subset that test is not required;
- 15 c) if a subset that requires test exists at the same level as the initial subset, selecting a subset on the same level as the initial subset; and

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d) if no subset that requires test exists at the same level as the initial subset, proceeding to another level and continuing the method from step b.

5 11. The method of Claim 1 wherein the second signal further comprises consistent redundant signals and each transceiver of the plurality further comprises means for disregarding a received signal that includes inconsistent redundant signals.

10 12. The method of Claim 11 wherein a transceiver of the plurality concludes that it was addressed by the second signal in response to the means for disregarding a received signal.

13. The method of Claim 11 wherein the second signal further comprises a command packet comprising a check code for one of the redundant signals.

15 14. The method of Claim 1 wherein a portion of the second signal is modulated responsive to the address of the subset.

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15. The method of Claim 14 wherein the second signal further comprises consistent redundant signals and each transceiver of the plurality further comprises means for disregarding a received signal that includes inconsistent redundant signals.

5 16. The method of Claim 15 wherein a transceiver of the plurality concludes that it was addressed by the second signal in response to the means for disregarding a received signal.

17. The method of Claim 1 wherein a portion of the reply signal is modulated responsive to the self designation.

10 18. The method of Claim 1 wherein repeatedly establishing a self designation produces consecutive self designations that show at most a pseudo-random order thereby reducing the probability of simultaneously establishing identical self designations in more than one transceiver of the plurality.

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19. The method of Claim 1 wherein the reply signal further comprises a reply packet and the self designation comprises a designation code in the reply packet.

5 20. The method of Claim 1 wherein the reply signal further comprises a reply packet including a Viterbi convolution code, and the first transceiver further comprises means for detecting a received signal that includes an inconsistent Viterbi code.

10 21. The method of Claim 1 wherein the reply signal further comprises consistent redundant signals, and the first transceiver further comprises means for detecting a received signal that includes inconsistent redundant signals.

15 22. In a system wherein a first transceiver and a plurality of transceivers are coupled to a medium for communication on which a collision occurs when more than one transceiver of the plurality transmits simultaneously, each transceiver of the plurality comprising means for being addressed responsive to

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a self designation selected from a predetermined set of designations, the first transceiver comprising means for addressing transceivers, means for requesting reply transmissions from a subset of the plurality and means for detecting a collision, a method for reducing the likelihood of collision comprising the steps of:

- 5 a) transmitting from the first transceiver a first signal addressing a first subset of the set;
- 10 b) establishing, in each transceiver of the plurality that was addressed by the first signal, a self designation selected from the set;
- 15 c) transmitting from the first transceiver a second signal characterized by an address related to the self designation of one transceiver; and
- 20 d) entering a limited mode of operation in a transceiver of the plurality that was addressed by the second signal and remaining in the limited mode until after steps a and b recur, the transceiver while in the limited mode will not transmit the reply transmission;

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whereby the first transceiver reduces the number of transceivers that can reply when addressed and commands transceivers that established non-unique self designations at an earlier time to re-establish a self designation.

5 23. In a system for radio frequency identification, a method for communicating between an interrogator and a plurality of responders, the interrogator and each responder being coupled to a medium on which a collision occurs when more than one responder transmits simultaneously, the interrogator comprising a circuit for collision detection, the responder comprising a random number generator, the method comprising the steps of:

15 a) determining in each responder whether that responder is addressed by a command packet by comparing a first binary branch code to the logical AND of a self designation code and a first binary mask code;

b) transmitting from the interrogator a spread spectrum signal comprising a first command packet that includes the binary branch code and the binary mask code, the branch and

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mask codes having the same precision as the output of the random number generator;

5 c) storing, in each responder that was addressed by the first command packet, the output of the random number generator as the self designation code;

10 d) transmitting from the interrogator a second command packet that includes the binary branch code and the binary mask code, the branch and mask codes defining a subset selected by the interrogator in response to collision detection according to a method for selecting an untested subset after use of an initial subset, the method comprising the steps of:

15 1) if a collision occurred, dividing the initial subset into an untested right subset and an untested left subset, the initial subset becoming the immediate superset of the untested right subset, the untested right subset disjoint from the untested left subset and selecting the untested left subset whereby the untested left subset becomes a tested left subset;

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2) if a collision occurred and the initial subset cannot be divided or if a collision did not occur, selecting the untested right subset disjoint from the initial subset whereby the untested right subset becomes a tested right subset; and

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3) if a collision did not occur, considering individually each immediate superset of the initial set until a tested left subset is under consideration and selecting the untested right subset that is disjoint from the tested left subset under consideration;

e) determining in each responder whether that responder is addressed by the second command packet by comparing the second binary branch code to the logical AND of a self designation code and the second binary mask code;

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f) transmitting a spread spectrum reply packet from a responder that was addressed by the second command packet, the reply packet comprising the self designation code; and

g) entering a limited mode of operation in a responder that was addressed by a third command packet, the responder

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while in the limited mode will not transmit the reply transmission;

whereby the interrogator can determine the self designation of a responder.

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